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The Science Behind a Flipped Classroom

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### Abstract

When first asked to teach a flipped classroom, I was excited and apprehensive at the same time. I knew I always wanted to try it but I wasn't sure what the best practices were nor which parts of the class should be flipped and which shouldn't. I soon found out there is a lot more to flipping a classroom, but the results can be rewarding. In this paper, I will describe how I flipped a College Algebra class with a specific focus for nursing students. In addition, valuable ideas and best practices on how to effectively flip a class are presented.

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# The Science Behind a Flipped Classroom

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**Abstract.** When first asked to teach a flipped classroom, I was excited and apprehensive at the same time. I knew I always wanted to try it but I wasn't sure what the best practices were nor which parts of the class should be flipped and which shouldn't. I soon found out there is a lot more to flipping a classroom, but the results can be rewarding. In this paper, I will describe how I flipped a College Algebra class with a specific focus for nursing students. In addition, valuable ideas and best practices on how to effectively flip a class are presented.

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**Keywords.** best practices; flipped class; mathematics; mathematics education.

## Part 1. Math 21: Hybrid College Algebra I for Nursing Students

In the fall 2014, I was approached by my director asking if I would be interested in teaching a hybrid College Algebra course, which I gladly accepted. The course is part of the accelerated bachelor of nursing program at Penn State Behrend and I had to create a course with specific applications for nursing students. When first faced with this new endeavor, I knew I needed help from others. Reaching out to the various nursing instructors at Penn State Behrend, I gained a wealth of information on how to incorporate nursing applications into the class. When it came down to building the course online, I had help from my colleague, Jessica Resig, Director of World Campus Learning Design and Behrend Center for eLearning Initiatives. Through our collaborative efforts, the 7-week course was online and ready to go within a period of two months.

## Part 2. Pre-Reading to Understand the Nursing Profession

When finding out this would be a class for nursing students, I wanted to find out, specifically, how mathematics is used in the medical profession. In the medical field, the administration of medicines is a large part of a nurses job. With the 21st century, the times nurses are performing medical calculations have decreased, Hoiston (1996) estimated that at least one person dies each day in the United States due to medication errors. When first reading this, I strived to give my students all the mathematics they would need to be confident for their careers. In the nursing textbooks I have looked at, most of them present problems with formulas and having students substitute numbers without giving much thought about why they are calculating medical dosages. There are two large problems with this procedure. First, in a study done by

Hoyles, Noss, and Pozzi (2001) where twelve nurses were observed found the nurses mostly rely on proportional reasoning strategies. Although the nurses can remember formulas taught in their schooling years, they always returned to the methods of proportional reasoning to avoid any complex division and multiplication. The second problem with using the substitution method and formulas are outlined in the study by Blais and Bath (1992). Here, the conceptual errors in medication administration were more frequent than mathematical errors and measurement errors. The set-up of dosage calculations were of the more common type of error. Mistakes are made at any profession and are not unique to nurses. According to sociologist E. C. Hughes (1951), people working in all occupations make these errors and suffer a great deal of anxiety as a result. Wolf (1994) recalls how terrible she had felt when, Oh, my God! I pulled out the wrong one! The initial thought was to not tell anyone what happened, however, mistakes such as these in the nursing field must be reported. It is a matter of life and death.

### Part 3. Outline of Math 21

As the course was part of the accelerated bachelor program for nurses, the nursing department wanted the course to be 7 weeks long. Typically, Math 21 is a traditional 15-week course that meets for 50 minutes on Monday, Wednesday, and Fridays or Tuesday and Thursdays for 75 minutes. Teaching this course in a regular fall and spring semesters is hard enough to get through material in a 15-week semester, let alone, a 7-week semester. I needed to think about how to best split up the class to make sure all bluebook concepts were covered along with the nursing applications. In terms of the required concepts, the course needs to cover concepts of quadratic equations, equations in quadratic form, word problems, graphing, algebraic fractions, negative and rational exponents, and radicals. The class would meet every Thursday for 2.5 hours, so time was critical to say the least. With the nursing applications I received from the nursing department, I wanted to include topics on unit conversions, Bishops Score, Radon Gas Risks, Growth Charts for Boys aged 2–20 years, Girls Growth Charts from birth to 36 months old, Fahrenheit vs. Celsius, Incidence of Diabetes in Adults ages 45–64, Life Expectancy, Training Heart Rate Zones, BMI, Calculating pH, Spread of Viruses, Cancer Cell Simulation, and Eliminating Medicine from the Bloodstream. As we can see, I had a lot of good topics to work with. Please see the appendix for the outline of Math 21.

During Week I, I showed students a PowerPoint on Scientific Notation, Linear Inequalities, Compound Inequalities, Absolute Value Equations, and Absolute Value Inequalities. However, for all other weeks, students were required to view video lectures I had created under the guidance of my colleague Dr. Jessica Resig.

### Part 4. Course Development

By renting an iPad from the Behrend library, I created all videos using Doceri. When starting this process, I soon found out this was going to be a time consuming process. What saved me some time were PowerPoints I had created from previous times I had taught the course. Taking out the solutions to each problem, saving and exporting the slides as jpegs via Dropbox, I would have the problem typed up and I went through the solutions for my lectures. Some of the lessons I learned about making video lectures were:

1. Timing consuming but once made, videos can be used over and over again.
2. Record videos in a place where no one will disrupt you.
3. I recorded my videos between 6–11 pm each day in my office. However, make sure all phones are disconnected.
4. Don't create long videos. Studies show, students are more inclined to view 5–7 minute videos instead of 15–20 minute videos.
5. Use software where you can edit mistakes.

6. Have a script ready. This will minimize errors.

Math 21 was being offered in the spring 2015 semester. I started and completed making all videos within a three-month period between October to December. In terms of homework and assessments, I used MyMathLab (MML). I had used MML in the past at other Universities before coming to Behrend and I knew how successful the software had been in previous courses. Using the book by Martin-Gay, *Intermediate Algebra* 6th edition, Pearson had a Ready-To-Go course available with the book. All assignments were premade with the option to edit. I went through and edited each assignment by cutting out and adding questions. I also set the requirement that all assignments have a passing rate of 80%. When it came down to face-to-face class time, I started each class with a check-up activity to make sure students watched the videos before coming to class. Since the students were in the accelerated nursing program, they were ready to answer questions and actively participated in discussions. After the check-ups, the applications were passed out and students worked in pairs. The class had a total of seven students so there were a lot of interactions between fellow classmates and myself. This environment of students working in their own zones of proximal development where ideas were exchanged worked exceptionally well for this class. If any work was not completed, students were given the opportunity to turn in any work the following week. I also accepted work until the end of the semester. My experience with teaching this course has been very eye opening and an experience I'm thankful I obtained in my teaching career. I will now share some best practices I have learned that can take any traditional course to a flipped class. Of course, readers of this paper may have other ideas on how to effectively flip a class.

## Part 5. The Science to Flipping a Class

When first asked to teach a hybrid class, I needed to learn what makes a hybrid class a hybrid class. According to Lorenzetti (2013), Instead of using class time to convey the basic information you want your students to remember and asking them to work on more difficult learning tasks alone, a flipped class asks students to come to class prepared with the foundational information and then to work on the challenging tasks of analysis, evaluation, and creation with others. When first starting to think about how to flip a class, which I had never previously done in my career, I had to think back to how college works. While going through my college career, I had to take my own initiative and learn things on my own. After a 50 minute class, I would spend 3-4 hours working out problems, re-working my notes, finding additional resources to make them work to aid my learning. Then, in class, I would ask follow-up questions to further engage myself to get the most out of my learning. What I have outlined above was my starting point to creating my hybrid class. The learning was placed on the students so that when they came into class, they were ready for the check-ups and to apply their knowledge to nursing applications. If we think about it, we as faculty spend many hours helping our students in office hours and answering emails. With a flipped class, the instructor can work with students directly as if they are in a big office hour. This, of course, will vary on class size. As Hill (2013) points out, Faculty can then devote time to helping students develop synthesis and explore application during class time through: experiential exercises, team projects, problem sets, and activities that previously have been assigned as independent homework. In particular, students can receive direct faculty input on those segments of the material that have historically been the most [difficult] or ambiguous. When teaching my flipped class, I found that topics such as factoring trinomials were easier for students to understand, especially when factoring trinomials where the leading coefficient was not one. With using colors on the video and having the check-up for this concept alone, I saw a great improvement in students being able to know what to do to and to solve the problem faster than in a face-to-face class. However, as with teaching any class, the students must be driven to work. As Ullman (2013) points out, It requires students to be independent. It's an excellent growth opportunity, but the student has to be willing to put in the time and be

an active participant in the learning. Some [students] listen, do a little homework, and get by. That won't cut it in the flipped classroom. In a flipped classroom, it is imperative to convey to your students that the course is NOT a traditional face-to-face class. Caldarera (2013) writes, The flipped classroom format, [students] will be expected to complete the lesson as homework. All instructions are to be followed so as to allow more time for engaging enrichment activities in class. One important piece of advice I would like to share is to send out a welcoming email to the students before class begins. The email I sent out was the following: Dear Nurses, I would like to welcome you to Math 021: College Algebra I taught via the hybrid learning platform. My name is Professor Peter Olszewski and I will be your instructor for this class. I hope everyone is excited to start as I am. I wanted to send out a welcoming announcement about what we will be covering in the next seven weeks and my tips for success. Math 021 covers the following topics

1. Graphs, functions, and solving absolute value equations.
2. Polynomials and Factoring.
3. Rational Expressions, Equations, and Functions.
4. Radicals.
5. Quadratic Equations and Functions.
6. Sequences, Series, and the Binomial Theorem.

In terms of nursing applications, we will cover...

1. Unit conversions.
2. Bishop's score.
3. Radon gas risks.
4. Growth charts for boys 2 - 20 years & girls birth - 36 months.
5. Diabetes in adults ages 45 - 64.
6. Life expectancy.
7. Protein intake.
8. Heart rates.
9. BMI.
10. Spread of viruses.
11. Cancer cell growth.
12. Eliminating medicine from the bloodstream.

We will be using MyMathLab (MML) software for all homework assignments, quizzes, and exams. The start of each week will be on Thursdays and end the following Wednesday. My tips for success for this course and beyond are to....

1. RRR and SSS, which stands for Read, Read, Read, and Solve, Solve, Solve. The more you read, the examples, definitions, methods and the more you practice with solving the problems, the better you'll be! Practice makes perfect.
2. Be sure to take the time to read the information in the weekly assignments carefully. Everything you need to know is included in these areas.
3. Ask for help whether it is in the Problems and Solutions thread, weekly discussion threads, calling, or emailing me for help. Chances are, if you are stuck on a question, your fellow peers might also be stuck on the same question. Don't be afraid to ask!
4. Actively participate in ALL discussions. The more you chat about what you are thinking about to solve a problem, the better you'll understand it through comments from either myself or from fellow classmates.
5. Take your time when doing the exams. There are no extra bonus points awarded for blazing through exams in 15 minutes by getting half the answers wrong.
6. Check your work. If you get an answer to a problem, do it again to see if you get the same answer. If the problem requires you to solve an equation to get the value of a variable, substitute the value back into the equation to see if the equation still holds.

7. Get a calculator. If you don't already have one, a TI-83 or TI-84 would be good to have for future mathematics courses since they can graph functions. I know these calculators are pricy but they will be worth it in the long run. However, a simple calculator will work. I recommend the TI-30.
8. Buy some graph paper, a ruler, and pencils. These will help you with the graphing problems.
9. If you get frustrated on a problem, write out all the steps you took to solve the problem and either call or email me. By showing your work, I can quickly go through and see where you went astray.

It is great having all of you in class this semester. I hope you are looking forward to the course as much as I am!

Sincerely,

Professor Olszewski

In teaching this course, I have found that having this email and talking to students on day one about the course proved to be very helpful. Of course, the students I had for this course had taken other hybrid classes in the past and knew they needed to work hard. If you have a class of students who have never had a hybrid class they may be overwhelmed and even walkout on the first day. I have found that the student, who is driven to learn on their own, is willing to discover, and wants to be the best they can be, will thrive in a hybrid class. With my experience, I offer the following best practices to flipping your own class with the emphasis not all these ideas may work for every class and instructor:

1. **Make the class personal.** Often times, the only time your students will see you lecturing is through video lecturers. Try to make the videos, as you would want to be seen if you were being recorded for a giving a talk at a conference. Keep it professional but fun.
2. **Make it engaging.** When students are looking at your videos, if they find them boring, they will be more likely to resort to other videos to obtain information.
3. **Make it short and segmented.** As stated earlier, videos should not be long, as students will become disengaged after 10 minutes. This is true of video lecturers and face-to-face lecturers.
4. **Make it relevant.** As in a face-to-face class, the key to a successful flipped classroom is to relate problems to real-life applications. In Math 21, I had no problem creating applications for nursing students.
5. **Make it a two-way street.** Although I didnt try this, what Im thinking about for the next time I teach the class is to have students make their own videos or to come up with exam problems or critique other students work. This way, students have more control over their own learning.
6. **Have an introductory video about a flipped classroom.** I also didnt try this but to create a video where a flipped class is explained may help students understand how the class will run before the first day of the semester.
7. **Take attendance.** I didnt have a problem with attendance in my class but I can see it being a big problem for other classes. With a flipped class, the student must be present. I see a student missing a flipped class as being the same as missing a physics lab, which is very hard to make up. Also, give a grade reduction for students who do miss class.
8. **Unprepared students.** Students who dont watch videos or read the text before coming to class can cause a huge disruption. Here, make a seating chart and keep track of the students who are not prepared for the week. Offer one chance to redeem themselves and ask students questions the next class period instead.
9. **Dont assign too much homework.** Before starting the class, think about which problems test the concepts more than others. Remember, students are doing twice as much work outside of class while in a flipped class. You want to have clear goal on what you want

students to be able to do at the end of the semester. In short, developing learning goals is vital.

10. **Access to materials online.** Although it is 2015, some students still don't have regular access to computers. At the start of the semester, stress to students that they must have access to a computer either through family/friends or at public libraries or at school. Not having computer access is simply a no-go for a flipped class.
11. **Lots of prep work for the instructor.** When first faced with creating a hybrid class, you as the instructor need to devote a lot of time to preparing the class. The ideal time to prepare for a flipped class would be over the summer as the three months or so will give plenty of time to get videos, activities, announcements, syllabus, assessments, and homework ready to go.
12. **Monitor students work online.** With MML, it is very easy to see who is doing the work and who isn't. Stress to students deadlines and have a clear policy in place about late work. Also, talk to your IT specialists to see how you can monitor who watches video lectures to make sure they are being watched.
13. **Large classes.** Although I have not had a personal experience in teaching a class larger than 50 students, I don't see how a flipped class of say, 300 students, would work. Sometimes, a class shouldn't be flipped.
14. **Allow feedback.** When teaching the course for the first time, I gave three feedback forms to my students to complete on ANGEL. The more feedback I received, the better the class went.
15. **Talk to fellow colleagues about their experiences.** Often times, the person next door to your office can provide you with a great wealth of experience. Don't be afraid to ask for advice.
16. **You are still the professor.** Even though the learning of the concepts happens outside the classroom, you are still the professor guiding students along and offering your wealth of knowledge in the face-to-face time with the students. Don't be discouraged about the new way of running your hybrid class vs. your traditional class, embrace it!
17. **If things go wrong.** Not everything will go right. Learn from your mistakes and try again.

## Part 6. Conclusion

In conclusion, I can honestly say I have learned a great deal about myself through teaching my first hybrid class. When I made my first video and I heard it play back, I deleted it right away, as I couldn't believe how boring I sounded. It made me realize how I needed to change to get the students involved outside of class. The energy and enthusiasm I always have in a face-to-face class needed to be transferred in a new arena where students could think without my physical presence. I would highly encourage anyone who is thinking of trying the flipped classroom approach to not waste time thinking about, but to do it. It will make you stop and think about how to deliver your teaching in a new light.

**Acknowledgements:** I would like to thank my collaborator, Jessica Resig for helping me put the hybrid course together using ANGEL and for always giving me support throughout this exciting process.

## Appendix A: Outline of Math 21

Week	Topics	Group Application Problems
<b>Thursday, January 15, 2015 Week I</b>	<ol style="list-style-type: none"> <li>1. Set-up MML accounts.</li> <li>2. Scientific Notation.</li> <li>3. Linear Inequalities.</li> <li>4. Compound Inequalities.</li> <li>5. Absolute Value Equations.</li> <li>6. Absolute Value Inequalities.</li> </ol>	<ol style="list-style-type: none"> <li>1. Unit Conversion Lab.</li> <li>2. Bishop's Score.</li> <li>3. Radon Gas Risks.</li> <li>4. Growth Charts, Boys 2 - 20 years &amp; Girls birth – 36 months.</li> <li>5. Metric Mania.</li> <li>6. Dosage Calculation Worksheet</li> </ol>
<b>Thursday, January 22, 2015 Week II</b>	<ol style="list-style-type: none"> <li>1. <i>MML Homework, § 2.4 – 2.7 Due.</i></li> <li>2. <i>Post-Test on Chapter 2 Due.</i></li> <li>3. Graphing Equations.</li> <li>4. Introduction to Functions.</li> <li>5. Graphing Linear Functions.</li> <li>6. The Slope of a Line.</li> <li>7. Equations of Lines.</li> <li>8. Graphing Piece-wise-Defined Functions, Shifting, &amp; Reflecting Graphs of Functions.</li> <li>9. Graphing Linear Inequalities.</li> </ol>	<ol style="list-style-type: none"> <li>1. Fahrenheit vs. Celsius.</li> <li>2. Incidence of Diabetes in Adults Ages 45 – 64.</li> <li>3. Life Expectancy parts I-II.</li> <li>4. Protein Intake.</li> <li>5. Training Heart Rate Zones.</li> <li>6. Graph of Heart Rate over Time.</li> </ol>
<b>Thursday, January 29, 2015 Week III</b>	<ol style="list-style-type: none"> <li>1. <i>MML Homework, § 3.1 – 3.7 Due.</i></li> <li>2. <i>Post-Test on Chapter 3 Due.</i></li> <li>3. Exponents &amp; more on Scientific Notation.</li> <li>4. Polynomials and Polynomial Functions.</li> <li>5. Multiplying Polynomials.</li> <li>6. The Greatest Common Factor and Factoring by Grouping.</li> <li>7. Factoring Trinomials.</li> <li>8. Factoring by Special Products.</li> <li>9. Solving Equations by Factoring and Problem Solving.</li> </ol>	Class will be working on MML homework, applications within MML.
<b>Thursday, February 5, 2015 Week IV</b>	<ol style="list-style-type: none"> <li>1. <i>MML Homework, § 5.1 – 5.8 Due.</i></li> <li>2. <i>Post-Test on Chapter 5 Due.</i></li> <li>3. Rational Functions, Multiplying, &amp; Dividing Rational Expressions.</li> <li>4. Adding &amp; Subtracting Rational Expressions.</li> <li>5. Simplifying Complex Fractions.</li> <li>6. Solving Equations Containing Rational Expressions.</li> <li>7. Rational Equations &amp; Problem Solving.</li> <li>8. Variation &amp; Problem Solving.</li> <li>9. Radicals and Radical Functions.</li> <li>10. Rational Exponents.</li> <li>11. Simplifying Radical Expressions.</li> <li>12. Adding, Subtracting, &amp; Multiplying Radical Expressions.</li> <li>13. Rationalizing Denominators &amp;</li> </ol>	<ol style="list-style-type: none"> <li>1. Textbook applications.</li> <li>2. Variation applications (non-nursing examples).</li> </ol>



	Numerators of Radical Expressions. 14. Radical Equations & Problem Solving.	
<b>Thursday, February 12, 2015 Week V</b>	1. <b><i>MML Homework, § 6.1 – 6.3, 6.5 – 6.7, &amp; 7.1 – 7.6 Due.</i></b> 2. <b><i>Post-Test on Chapters 6 &amp; 7 Due.</i></b> 3. Solving Quadratic Equations by Completing the Square. 4. Solving Quadratic Equations by the Quadratic Formula. 5. Solving Equations by Using Quadratic Methods. 6. Quadratic Functions & Their Graphs. 7. Further Graphing of Quadratic Functions.	1. Additional Life Expectancy. 2. Heart Rate Data. 3. More on Heart Rate. 4. More on BMI. 5. Applications to Quadratics (non-Nursing examples).
<b>Thursday, February 19, 2015 Week VI</b>	1. <b><i>MML Homework, § 8.1 – 8.3 &amp; 8.5 – 8.6 Due.</i></b> 2. <b><i>Post-Test on Chapter 8 Due.</i></b> 3. Exponential Functions. 4. Exponential Growth & Decay. 5. Logarithmic Functions. 6. Properties of Logarithms. 7. Common Logarithms, Natural Logarithms, & Change of Base Formula. 8. Exponential & Logarithmic Equations & Problem Solving.	1. Calculating pH. 2. Spread of a Virus. 3. Compound Interest applications (non-nursing examples). 4. Scientific Applications with continuous compound formula. 5. Cancer Cell Simulation.
<b>Thursday, February 26, 2015 Week VII</b>	1. <b><i>MML Homework, § 9.3 – 9.8 Due.</i></b> 2. <b><i>Post-Test on Chapter 9 Due.</i></b> 3. Sequences. 4. Series. 5. The Binomial Theorem. 6. Review for Final Exam. 7. <b><i>Post-Test on Chapter 11 Due on 3/1 at 11:59 pm.</i></b>	1. Eliminating Medicine from the Bloodstream.

## References

- [1] K. BLAIS AND J. BATH, *Drug calculation errors of baccalaureate nursing students*, *Nurse Educator* 17(1) (1992).
- [2] L. CALDARERA, *Flipped classroom - best practices*, Retrieved from <http://prezi.com/-yrrp4lyodap/flipped-classroom-best-practices/> (2013).
- [3] C. HILL, *The benefits of flipping your classroom*, Retrieved from <http://www.facultyfocus.com/articles/instructional-design/the-benefits-of-flipping-your-classroom/> (2013).
- [4] S.S. HOISTON, *FDA focused on drug and device errors*, *Journal of the American Medical Association* 276(16) (1996) 1287.
- [5] C. HOYLES, R. NOSS AND S. POZZI, *Proportional reasoning in nursing practice*, *Journal for Research in Mathematics Education* 32(1) (2001) 4 - 27.
- [6] E.C. HUGHES, *Mistakes at work*, *Journal of Economics and Political Science* 17 (1951) 187 - 196.
- [7] J. LORENZETTI, *How to create assessments for the flipped classroom*, *Journal of Economics and Political Science*, Retrieved from <http://www.facultyfocus.com/articles/instructional-design/how-to-create-assessments-for-the-flipped-classroom/> (2013).
- [8] E. ULLMAN, *Tools and tips for the flipped classroom*, Retrieved from <http://www.techlearning.com/features/0039/tools-and-tips-for-the-flipped-classroom/53725> (2013).
- [9] Z.R. WOLF, *Medication errors: the nursing experience*, Delmar Publishers, Inc (1994).

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